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Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on
Geotechnical Investigation

Proposed
Synthetic Bowling Greens

Prepared for
Maitland City Bowls Sports and Recreation

Project 39498.06
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Douglas Partners
Geotechnics / Environment / Groundwater

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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		30 March 2015
Reviewer		30 March 2015

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Table of Contents

Page

Report on Geotechnical Investigation
Proposed Synthetic Bowling Greens
Melbee Street, Rutherford

1. Introduction

This report presents the results of a geotechnical investigation for the upgrade of the existing No. 1 and No. 2 Bowling Greens located at Maitland City Bowling Club, Melbee Street, Rutherford, New South Wales. The work was carried out at the request of Mr Matt Johnston of Maitland City Bowls Sports and Recreation.

It is understood that the existing natural turf greens, No. 1 and No. 2 Bowling Greens, are to be replaced with a synthetic bowling green to include a new synthetic grassed surfaces at a similar level to the existing surfaces. It is further understood that the synthetic grassed bowling greens have relatively tight tolerances in the final surface levels.

A geotechnical investigation was undertaken to provide the following information:

- Subsurface conditions at within the proposed greens;
- Comments on potential lime stabilisation of subgrade materials for No. 1 Green;
- Comments on subgrade preparation methods;
- Recommendations for further investigation to allow detailed design, if required.

A waste classification was also undertaken concurrently with the geotechnical investigation. A separate report 39498.06.R.001 has been prepared for the waste classification assessment.

Douglas Partners have previous undertaken a geotechnical investigation for the upgrade of Green No. 2, report 39498.05, “Geotechnical Investigation, Proposed Synthetic Bowling Green, Melbee Street, Rutherford” dated 5 June 2014. The results from the previous investigation have been included in this report. It is understood from previous investigations that the site of the club was a former quarry that has been filled.

2. Site Description and Regional Geology

Maitland City Bowling Club is situated between Arthur Street and Melbee Street, Rutherford. The site is bound is bound by a retail precinct to the north, New England Highway to the west, parkland and fast food outlet to the north west and residential areas to the east and south.

The proposed synthetic bowling greens (about 37 m x 37 m in dimension for each green) are to be constructed in the location of the existing green No. 1 and No. 2 as shown on the attached Drawing 1. The site is shown in Figures 1 to 3 below.

Figure 1: Bowling Green No. 1 and No. 2 looking west

Figure 2: Bowling Green No. 2 looking south west

Figure 3: Looking north along western retaining wall

Reference to the 1:100, 000 Newcastle Coalfield Geology Map indicates that the site is underlain by Permian aged Branxton Formation of the Maitland Group which consists of conglomerate, sandstone and siltstone.

It is understood that the site of the bowling greens comprises an in filled quarry. Bowling club staff advised DP that a sinkhole formed in the bowling green No. 1 in the 1980s and was backfilled with several truckloads of concrete. Enquiries were made with the Mine Subsidence Board who indicated that the sinkhole was not related to mine subsidence as there are no recorded mine workings in the area. The sinkhole was possibly related to a local collapse or void within the quarry backfill.

3. Field Work

3.1 Methods

Field work was undertaken on 2 March 2015 and comprised the following:

- Drilling of six boreholes to depths of 0.4 m to 0.45 m using a 75 mm diameter hand auger (Bores 102, 104 and 106 to 109) at accessible locations;
- Drilling of three bores using a 3.5 tonne excavator with a 300 mm auger attachment to depths of 0.55 m to 1.6 m (Bores 101, 103 and 105) at accessible locations;
- Dynamic penetrometer tests at four of the bore locations;
- Collection of samples for laboratory testing and identification purposes;

The previous investigation (Ref 1) included the following:

- Drilling of four bores to depths of between 0.45 m and 1.3 m using a hand auger;
- Dynamic penetrometer tests at each bore location as well as two additional locations.

The test locations were set out from the edges of the existing bowling green and the location of each test is shown on Drawing 1, attached.

3.2 Results

The subsurface conditions encountered are presented in detail in the attached borehole logs. These should be read in conjunction with the attached accompanying notes which precede them and which explain the descriptive terms and classification methods used in the reports. The results from the current and previous investigation are summarised in Table 1 below.

Table 1: Summary of Subsurface Conditions

Test No.	Green No.	Depth Encountered Below Existing Ground Level (m)				
		Sandy Silt / Silty Sand Filling	Sandy Gravel / Gravel Filling	Clay Filling	Silty Clay / Clayey Silt	Bedrock
101	1	0.0 – 0.3	0.3 – 0.55	NE	NE	0.55
102	1	0.0 – >0.4	NE	NE	NE	NE
103	1	0.0 – 0.3	0.3 – 0.7	NE	0.7 – 1.6	1.6
104	1	0.0 – 0.3	0.3 – >0.45	NE	NE	NE
105	1	0.0 – 0.35	0.35 – 0.42*	0.42 – 1.4	NE	1.4
106	2	0.0 – 0.35	0.35 – >0.45	NE	NE	NE
107	2	0.0 – >0.4	NE	NE	NE	NE
108	2	0.0 – >0.45	NE	NE	NE	NE
109	2	0.0 – 0.3	0.3 – 0.4	NE	NE	NE
1[1]	2	0.0 – 0.35	0.35 – 0.8	0.8 – >1.1	NE	2.1#
2[1]	2	0.0 – 0.3	0.3 – 0.6	0.6 – 0.85	NE	0.85
3[1]	2	0.0 – 0.35	0.35 – >1.3	NE	NE	>3.0#

Notes to Table 1:
NE – Not encountered
1 – Previous investigation (Ref 1)
* Coal chitter with some slag
# inferred from Dynamic Penetrometer Test

A localised coal chitter layer was observed in Bore 105 from a depth of 0.35 m to 0.42 m. Trace coal chitter gravel was also observed in Bore 109 from a depth of 0.3 m to 0.5 m.

Seepage was observed at 0.35 m in Bore 101 at the location of the damaged slotted drainage pipe damaged during drilling. A perched water table was observed in Bore 2 from Ref 1 at a depth of 0.65 m. It is noted that groundwater levels are transient, being affected by several factors included recent rainfall, soil infiltration, surface topography and nearby recharge and abstraction points.

Monitoring of long term stabilised groundwater levels was beyond the scope of the current investigation.

4. Laboratory Testing

Laboratory testing on materials sampled included the following:

- One Standard compaction / 4-day soaked California bearing ratio (CBR) test on sandy gravel filling material;
- Five field moisture contents from the current investigation and 13 from the previous investigation;
- Two Atterberg limits and Linear Shrinkage tests on clay and clay filling materials; and
- Six unconfined compressive strength (UCS) tests on stabilised clay materials. The in-situ stabilisation trials involved stabilising the clay or clay filling with hydrated lime ($CA(OH)_2$ at rates of 1% and 3% and tested for a 7 day accelerated UCS. Four of the samples were soaked for a period of 4 hours prior to UCS testing as per the test method. Based on the results of these four tests, the remaining samples were tested un-soaked in an attempt to obtain results.

The detailed results of laboratory testing are attached. Summaries of the laboratory tests are given in Tables 2 to 4.

Moisture content tests were undertaken on samples collected from the bores to assess the variation in moisture profiles within the bores and across the site. Detailed laboratory test results are attached and are graphically represented in Figure 4 below.

Table 2: Summary of CBR Results

Bore	Depth (m)	Description	FMC (%)	SOMC (%)	SMDD (t / m^3)	CBR (%)	Swell (%)	Oversize (%)
103	0.6	Filling – Brown gravelly sand	9.7	5.5	1.83	19	-0.2	0.0

Notes to Table 2:
FMC - Field Moisture Content
SOMC - Standard Optimum Moisture Content
SMDD - Standard Maximum Dry Density
CBR - California Bearing Ratio (4 day soaked)
Oversize – Percentage of material retained on 19.0 mm AS sieve

Table 3: Laboratory Test Results – UCS

Bore	Depth (m)	SOMC (%)	SMDD (t/m^3)	UCS (MPa) (1%#)	UCS (MPa) (3%#)
103	0.75	21.5	1.63	-	0.1
105	0.5	20.5	1.66	NR	-
105	0.5	19.0	1.68	-	NR
105	1.0	17.5	1.74	0.0	-
105	1.0	17.0	1.76	-	NR
105	1.3	15.5	1.77	-	0.1

Notes to Table 3:
hydrated lime
SOMC - Standard Optimum Moisture Content
SMDD - Standard Maximum Dry Density.
UCS – Unconfined Compressive Strength (7 day accelerated curing).
NR – No result

Table 4: Summary of Atterberg Limit and Moisture Content Tests

Location	Sample Depth (m)	Material Type	FMC (%)	Linear Shrinkage (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
Bore 103	0.6	Filling – Brown Gravelly Sand	9.7	-	-	-	-
Bore 103	0.75	Silty Clay – Orange Brown	23.3	16.5	61	12	49
Bore 105	0.5	Filling – Orange Brown Clay	25.7	14.0	65	11	54
Bore 105	1.0	Filling – Orange Brown Clay	23.9	-	-	-	-
Bore 105	1.3	Filling – Orange Brown Clay	19.5	-	-	-	-

Notes to Table 4:
FMC – Field Moisture Content
WL – Liquid Limit
WP – Plastic Limit
PI – Plasticity Index
LS – Linear shrinkage

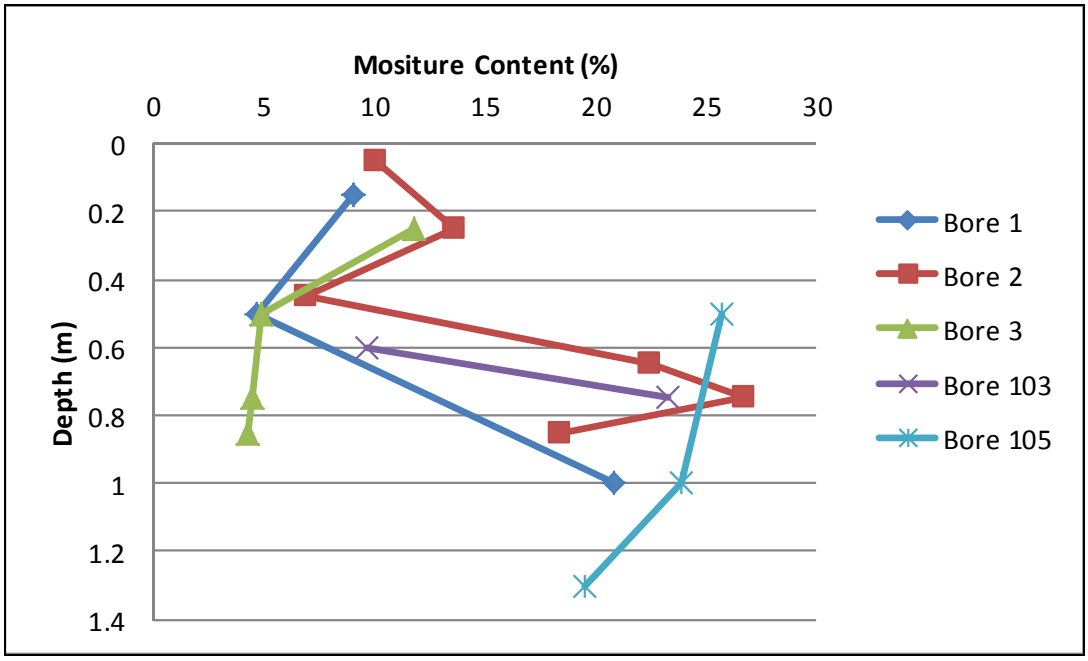


Figure 4: Moisture content variation with depth

Figures 5 to 11 show examples of the samples after lime stabilisation.

Figure 5: Bore 105/0.5 m 1% Lime – Sample B

Figure 6: Bore 105/0.5 m 3% Lime – Sample A

Figure 7: Bore 105/0.5 m 3% Lime – Sample B

Figure 8: Bore 105/1.0 m 3% Lime – Sample B

Figure 9: Bore 105/1.0 m 3% Lime – Sample B

Figure 10: Bore 105/1.0 m 3% Lime – Sample 1A (un-soaked prior to testing)

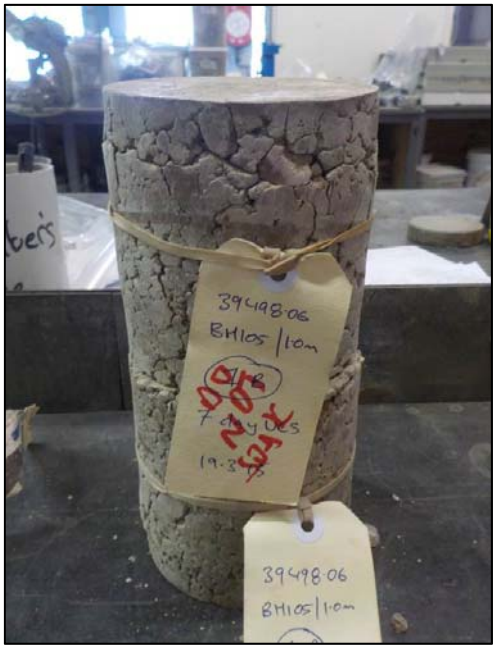


Figure 11: Bore 105/1.0 m 3% Lime – Sample 1B (un-soaked prior to testing)

5. Comments

5.1 General

Significant features with regard to subsurface conditions include:

- Silty sand filling was encountered to a depth of between 0.42 m and greater than 1.3 m;
- Wet sandy gravelly clay and clay filling beneath the granular filling;
- Dynamic penetrometer tests suggest existing filling was encountered is poorly compacted;
- Dynamic penetrometer tests indicate that subsurface conditions improved at depths of 0.55 m to 3 m as indicated by refusal of the dynamic penetrometer;
- Stabilisation of the clay / clay filling with at the rates of lime tested was not successful and the treated material was still sensitive to changes in moisture. The results suggest that the clay soils at this site would require a significantly higher proportion of lime to be effective;
- Indicative settlement criteria of ± 2 mm under a 3 m long straight edge over a 20 year design life has been provided by the client. It should be noted that only in the most ideal of geotechnical conditions that this settlement criteria would be able to be met. Characteristic surface movement associated with seasonal moisture change would likely induce a movement much greater than the above settlement criteria where a clay subgrade is encountered.

5.2 Subgrade Preparation

Based on the results of the dynamic penetrometer tests and bores, the subsurface conditions comprise very loose and loose sandy gravel filling and soft clay filling. There is a risk that if these soils are left in place, they will undergo settlement leading to an uneven playing surface. Furthermore, there is also a risk that these soils may cause some construction difficulties if vehicles traffic the subgrade during placement of the synthetic turf.

Accordingly, two subgrade preparation options are provided below in order of increasing risk of settlement.

5.2.1 Option 1 – Low Risk of Long-Term Settlement

The following subgrade preparation option is a low risk approach that will facilitate construction and minimise long-term settlement of the playing surface:

- Stop all watering practices as early as possible before the reconstruction of the greens;
- Strip existing vegetation from the surface followed by excavation of underlying sand filling;
- Stripping of underlying sandy gravel and wet / firm clayey filling which should be carried out using an excavator equipped with a smooth blade bucket to reduce disturbance and potential softening of the stripped surface. The depth of stripping would be subject to geotechnical inspection and moisture conditions during construction. Based on the results of the investigation, the following stripping depths below surface levels are suggested for costing purposes:

Table 5: Indicative Depths for Stripping

Test	Depth of Stripping Below Existing Surface Levels (m)
101	0.55
102	0.9
103	1.1
103A	1.0
104	1.8
105	1.4
1	1.4
2	0.6
3	2.0
5	1.2
6	0.75

- Care would be required to minimise undercutting the perimeter concrete paths. In this regard, the short term batters of the excavation should be batter at no steeper than 1V:1.5H. Where excavation is required adjacent to structures, the excavation should be undertaken in small sections (about 3 m to 5 m in length) and immediately backfilling with approved compacted material;
- Rubber tyred vehicles should be kept off the exposed subgrade to minimise additional softening;
- A layer (0.3 m thick) of compacted low permeable granular filling such as ridge gravel could be placed as the initial layer in order to provide an adequate subgrade to support additional layers. This material should compacted to at least 98% Standard dry density ratio;
- Compaction of the initial layer should involve thorough surface rolling (about eight passes) with at least 6 tonne roller in static mode the surface of the initial layer should be graded to the outside edges towards subsoil drainage;
- Fill to the required subgrade level for the synthetic green with additional filling comprising free draining low plasticity material, placed and compacted as above in layers not exceeding 300 mm loose thickness, to at least 98% Standard dry density ratio, with the upper 300mm compacted to 100% Standard dry density ratio.

5.2.2 Option 2 – Higher risk of long term settlement

An alternative to the above option would be to leave some of the existing soft clayey filling and rework the surface of the sand subgrade material. This option has a higher risk in terms of settlement and construction difficulties, particularly if poor construction techniques and materials are used. This option requires the owner to accept the risk of some surface settlement and deformation due to the presence of the soft / saturated filling. The subgrade preparation procedure for this option is:

- Stop all watering practices as early as possible before reconstruction of the greens and allow the sand and gravel to drain although this could take a long time to effectively dry;
- Excavate to select subgrade level, approximately 0.5m below the synthetic green subgrade level, as outlined in Table 6 below, followed by geotechnical inspections to assess whether further excavation is needed;
- Place geofabric and geogrid in base of excavation to act as a bridging layer over the poor subgrade;
- Place approved select subgrade material in layers of about 200 mm loose thickness and compact to at least 100% Standard dry density ratio;
- Place aggregate drainage layer and base layer for the synthetic green in accordance with designer's and / or manufacturer's requirements;
- Care is required to minimise undercutting the perimeter concrete paths. In this regard, the short term batters of the excavation should be batter at no steeper than 1V:1.5H. Where excavation is required adjacent to structures, the excavation should be undertaken in small sections (about 3 m to 5 m in length) and immediately backfilling with approved compacted material;

Machinery used on the site should comprise light tracked vehicles to reduce the risk of surface heaving during construction.

Table 6 below provides a suggested formation profile.

Table 6: Suggested Formation Profile

Pavement Layer	Thickness (mm)
Playing Surface	As per Designer's / Manufacturer's Requirements
5 mm Aggregate (No fines) 3% cement stabilised	As per Designer's / Manufacturer's Requirement (assume 150)
Free draining aggregate	As per Designer's / Manufacturer's Requirement (assume 100 to 150)
Select Subgrade such as DGS40	500 to 600
Geogrid and Geofabric	Bidim A14 Geotextile and Tensar SS30 Geogrid (or similar)
Total	750 to 900

5.3 Subsoil Drainage

It is understood that the synthetic surface is designed to be highly permeable to minimise water ponding at the surface. Accordingly subsoil drainage should be installed to allow water to drain from the green area and to minimise softening of the underlying subgrade.

The subsoil drains should be installed around the perimeter of the green. Internal drains should also be installed at about 6 m centres at a depth of about 0.3 m i.e. base of the permeable layers and may be directed towards the outside drainage depending on grade and site levels.

The subsoil drains should also be installed around the perimeter of the green to intercept any other moisture within the filling, particularly from the floor of the existing quarry.

5.4 Inspections and Testing

All earthworks should be subject to an appropriate level of inspections and testing as defined in the earthworks code, AS3798-2007 (Ref 3). The handling and management of excavated fill for off-site disposal should be undertaken with reference to the waste classification report (39498.03.R.001) prepared concurrently with this report.

6. References

1. Douglas Partners Report 39498.05, (2014), "Geotechnical Investigation for Proposed Synthetic Bowling Green, Melbee Street, Rutherford", dated 5 June 2014.
2. Australian Standard AS 1289.5.2.1-2003, (2003), "Methods of testing soils for engineering purposes", Standards Australia.
3. Australian Standard AS 3798-2007, (2007),"Guidelines on Earthworks for Commercial and Residential Developments", Standards Australia.

7. Limitations

Douglas Partners Pty Ltd (DP) has prepared this report for this project at Melbee Street, Rutherford, NSW in accordance with DP proposal NCL150108-1 dated 23 February 2015 and order received from Mr Matt Johnston of Maitland City Bowls Sports and Recreation on 25 February 2015. This report is provided for the exclusive use of Maitland City Bowls Sports and Recreation for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the observed sub-surface conditions only at the specific sampling locations and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the Client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the environmental components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

About this Report
Sampling Methods
Soil Descriptions
Symbols and Abbreviations
Borehole Logs (Bores 101 to 109)
Results of Dynamic Penetrometer Testing

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Soil Descriptions

Douglas Partners

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.

Symbols & Abbreviations

Douglas Partners

Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core Drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

Graphic Symbols for Soil and Rock

General


Asphalt


Road base


Concrete


Filling

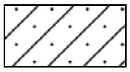
Soils


Topsoil

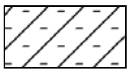

Peat


Clay

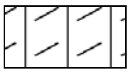

Silty clay

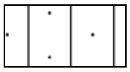

Sandy clay

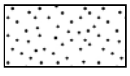

Gravelly clay

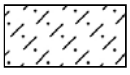

Shaly clay

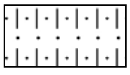

Silt


Clayey silt


Sandy silt

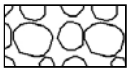

Sand

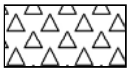

Clayey sand


Silty sand


Gravel


Sandy gravel


Cobbles, boulders

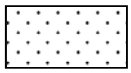

Talus

Sedimentary Rocks

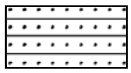

Boulder conglomerate

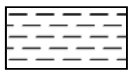

Conglomerate


Conglomeratic sandstone

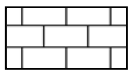

Sandstone


Siltstone


Laminite

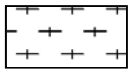

Mudstone, claystone, shale

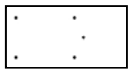

Coal


Limestone

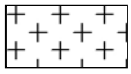
Metamorphic Rocks

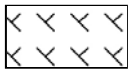

Slate, phyllite, schist

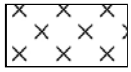

Gneiss

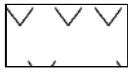

Quartzite

Igneous Rocks


Granite


Dolerite, basalt, andesite


Dacite, epidote


Tuff, breccia


Porphyry

BOREHOLE LOG

CLIENT: Maitland City Bowls Sports and Recreation
PROJECT: Geotechnical Investigation & Waste Classification
LOCATION: Maitland City Bowling Club, Melbee Street, Rutherford

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 101
PROJECT No: 39498.06
DATE: 2/3/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.04	FILLING - Generally comprising dark brown fine grained sandy silt filling with rootlets, moist							
		FILLING - Generally comprising brown, grey-brown fine grained sand filling, trace silt, trace fine to medium sized subrounded gravel		E	0.15		PID <1		
		From 0.2m, fine to coarse grained sand							
	0.3	FILLING - Generally comprising grey fine grained subrounded gravel filling, some sand, damp						▷	
		At 0.35m, 100mm diameter ag pipe							
	0.55	Bore discontinued at 0.55m, refusal on low strength sandstone							
	1								1
	2								2

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Kobelco 3.5 tonne
DRILLER:
LOGGED: Benson
CASING: Uncased

TYPE OF BORING: 300mm Diameter Auger

WATER OBSERVATIONS: Seepage at 0.35m

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Maitland City Bowls Sports and Recreation
PROJECT: Geotechnical Investigation & Waste Classification
LOCATION: Maitland City Bowling Club, Melbee Street, Rutherford

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 102
PROJECT No: 39498.06
DATE: 2/3/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.02	FILLING - Dark grey fine grained sandy silt filling, moist							
		FILLING - Generally comprising grey-brown fine grained sand filling, trace silt, trace fine to medium subrounded gravel, moist		E	0.3		PID <1		
	0.4	Bore discontinued at 0.4m, limit of investigation							
	1								
	2								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Hand Tools **DRILLER:** Peade **LOGGED:** Peade **CASING:** Uncased
TYPE OF BORING: 75mm Diameter Hand Auger
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Maitland City Bowls Sports and Recreation
PROJECT: Geotechnical Investigation & Waste Classification
LOCATION: Maitland City Bowling Club, Melbee Street, Rutherford

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 103
PROJECT No: 39498.06
DATE: 2/3/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.04	FILLING - Generally comprising dark brown fine grained sandy silt filling with rootlets, moist							
		FILLING - Generally comprising brown, grey-brown fine grained sand filling , trace silt, trace fine to medium subrounded gravel		E	0.2		PID<1		
	0.3	FILLING - Generally comprising brown, fine to coarse grained sandy fine to medium sized subrounded gravel (river gravel), wet		B	0.6				
	0.7	SILTY CLAY - Stiff, orange-brown silty clay, M>Wp		B,pp	0.75		pp = 110-240	▽	
1		From 0.9m, very stiff From 1.0m, yellow-brown							1
	1.1	CLAYEY SILT - Hard, yellow-brown clayey silt, M<Wp							
		From 1.3m, grading to siltstone							
	1.6	Bore discontinued at 1.6m, limit of investigation, refusal on siltstone							
2									2

RIG: Kobelco 3.5 tonne **DRILLER:** **LOGGED:** Benson **CASING:** Uncased
TYPE OF BORING: 300mm Diameter Auger
WATER OBSERVATIONS: Seepage at 0.7m
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

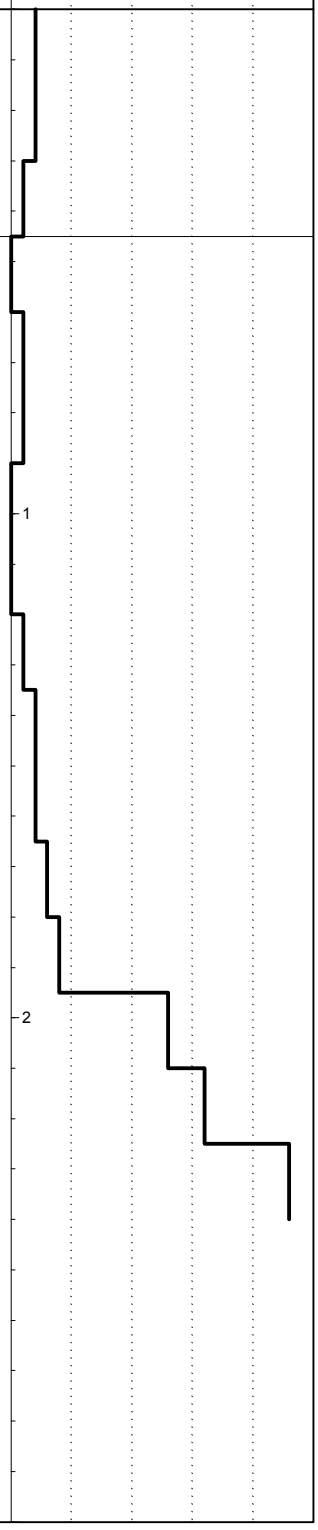
BOREHOLE LOG

CLIENT: Maitland City Bowls Sports and Recreation
PROJECT: Geotechnical Investigation & Waste Classification
LOCATION: Maitland City Bowling Club, Melbee Street, Rutherford

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 104
PROJECT No: 39498.06
DATE: 2/3/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.02	FILLING - Dark grey fine grained sandy silt filling, moist							
		FILLING - Generally comprising grey-brown fine grained sand filling, trace silt, trace fine to medium subrounded gravel, moist		E	0.1		PID <1		
		From approximately 0.3m to 0.35m, gravel content increasing		E	0.4		PID <1		
	0.45	Bore discontinued at 0.45m, limit of investigation							



RIG: Hand Tools **DRILLER:** Peade **LOGGED:** Peade **CASING:** Uncased
TYPE OF BORING: 75mm Hand Auger
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Maitland City Bowls Sports and Recreation
PROJECT: Geotechnical Investigation & Waste Classification
LOCATION: Maitland City Bowling Club, Melbee Street, Rutherford

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 105
PROJECT No: 39498.06
DATE: 2/3/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.04	FILLING - Generally comprising dark brown fine grained sandy silt with rootlets, moist		E	0.02		PID<1		
		FILLING - Generally comprising brown, grey-brown fine grained sand, trace silt, trace fine to medium sized subrounded gravel		E	0.2		PID<1		
	0.35	FILLING - Generally comprising coal chitter, some slag		E	0.35		PID<1		
	0.42	FILLING - Generally comprising orange-brown clay, trace silt, M>Wp		B,pp	0.42 0.5		pp = 90-150		
		From 0.8m, pale brown							
	1			B,pp	1.0		pp = 80-120		1
		From 1.2m, some silt (possible natural)							
				B,pp	1.35		pp = 100-150		
	1.4	Bore discontinued at 1.4m, limit of investigation, refusal on siltstone							
	2								2

RIG: Kobelco 3.5 tonne **DRILLER:** **LOGGED:** Benson **CASING:** Uncased
TYPE OF BORING: 300mm Diameter Auger
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⊻	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Maitland City Bowls Sports and Recreation
PROJECT: Geotechnical Investigation & Waste Classification
LOCATION: Maitland City Bowling Club, Melbee Street, Rutherford

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 106
PROJECT No: 39498.06
DATE: 2/3/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.02	FILLING - Dark grey fine grained sandy silt filling, moist							
		FILLING - Generally comprising grey-brown silty fine grained sand filling, moist		E	0.1		PID <1		
		From approximately 0.35m, some subrounded gravel and coarse grained sand		E	0.4		PID <1		
	0.45	Bore discontinued at 0.45m, limit of investigation							
	1								1
	2								2

RIG: Hand Tools **DRILLER:** Peade **LOGGED:** Peade **CASING:** Uncased
TYPE OF BORING: 75mm Hand Auger
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Maitland City Bowls Sports and Recreation
PROJECT: Geotechnical Investigation & Waste Classification
LOCATION: Maitland City Bowling Club, Melbee Street, Rutherford

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 107
PROJECT No: 39498.06
DATE: 2/3/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.02	FILLING - Dark grey fine grained sandy silt filling, moist							
		FILLING - Generally comprising grey-brown silty fine grained sand filling, moist		E	0.2		PID <1		
				E	0.35		PID <1		
	0.4	Bore discontinued at 0.4m, limit of investigation							
	1								1
	2								2

RIG: Hand Tools **DRILLER:** Peade **LOGGED:** Peade **CASING:** Uncased
TYPE OF BORING: 75mm Hand Auger
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Maitland City Bowls Sports and Recreation
PROJECT: Geotechnical Investigation & Waste Classification
LOCATION: Maitland City Bowling Club, Melbee Street, Rutherford

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 108
PROJECT No: 39498.06
DATE: 2/3/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.02	FILLING - Dark grey fine grained sandy silt filling, moist							
		FILLING - Generally comprising grey-brown silty fine grained sand filling, moist		E	0.1		PID<1		
				E	0.4		PID<1		
	0.45	Bore discontinued at 0.45m, limit of investigation							
	1								1
	2								2

RIG: Hand Tools **DRILLER:** Peade **LOGGED:** Peade **CASING:** Uncased
TYPE OF BORING: 75mm Hand Auger
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Maitland City Bowls Sports and Recreation
PROJECT: Geotechnical Investigation & Waste Classification
LOCATION: Maitland City Bowling Club, Melbee Street, Rutherford

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 109
PROJECT No: 39498.06
DATE: 2/3/2015
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.02	FILLING - Dark grey fine grained sandy silt filling, moist		E	0.0 0.02		PID <1		
		FILLING - Generally comprising grey-brown silty fine grained sand filling, moist		E	0.2		PID <1		
		From approximately 0.3m to 0.4m, some subangular gravel with trace coal chitter		E	0.35		PID <1		
	0.4	Bore discontinued at 0.4m, limit of investigation							
	1								1
	2								2

RIG: Hand Tools **DRILLER:** Peade **LOGGED:** Peade **CASING:** Uncased
TYPE OF BORING: 75mm Hand Auger
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⧗	Water level	V	Shear vane (kPa)

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Results of Dynamic Penetrometer Tests

Client	Maitland City Bowls Sports and Recreation	**Project No.**	39498.06
Project	Geotechnical Investigation and Waste Classification Assessment	**Date**	2/3/2015
Location	Maitland City Bowling Club, Melbee Street, Rutherford	**Page No.**	1 of 1

Test Locations	101	102	103A	104						
RL of Test (AHD)										
Depth (m)	**Penetration Resistance** Blows/150 mm									
0.00 – 0.15	2	2	3	2						
0.15 – 0.30	4	2	4	2						
0.30 – 0.45	15/90	1	3	1						
0.45 – 0.60		2	2	0						
0.60 – 0.75		2	1	1						
0.75 – 0.90		4	2	1						
0.90 – 1.05		5	5	0						
1.05 – 1.20		8	12	0						
1.20 – 1.35		11	15	1						
1.35 – 1.50		14	17	2						
1.50 – 1.65		18	18	2						
1.65 – 1.80		20	24	3						
1.80 – 1.95		20/100		4						
1.95 – 2.10				13						
2.10 – 2.25				16						
2.25 – 2.40				23						
2.40 – 2.55										
2.55 – 2.70										
2.70 – 2.85										
2.85 – 3.00										
3.00 – 3.15										
3.15 – 3.30										
3.30 – 3.45										
3.45 – 3.60										

Test Method AS 1289.6.3.2, Cone Penetrometer ☑ **Tested By** IDB
AS 1289.6.3.3, Sand Penetrometer ☐ **Checked By** **IDB**

Remarks Ref = Refusal, 25/110 indicates 25 blows for 110 mm penetration

Appendix B

Laboratory Test Results

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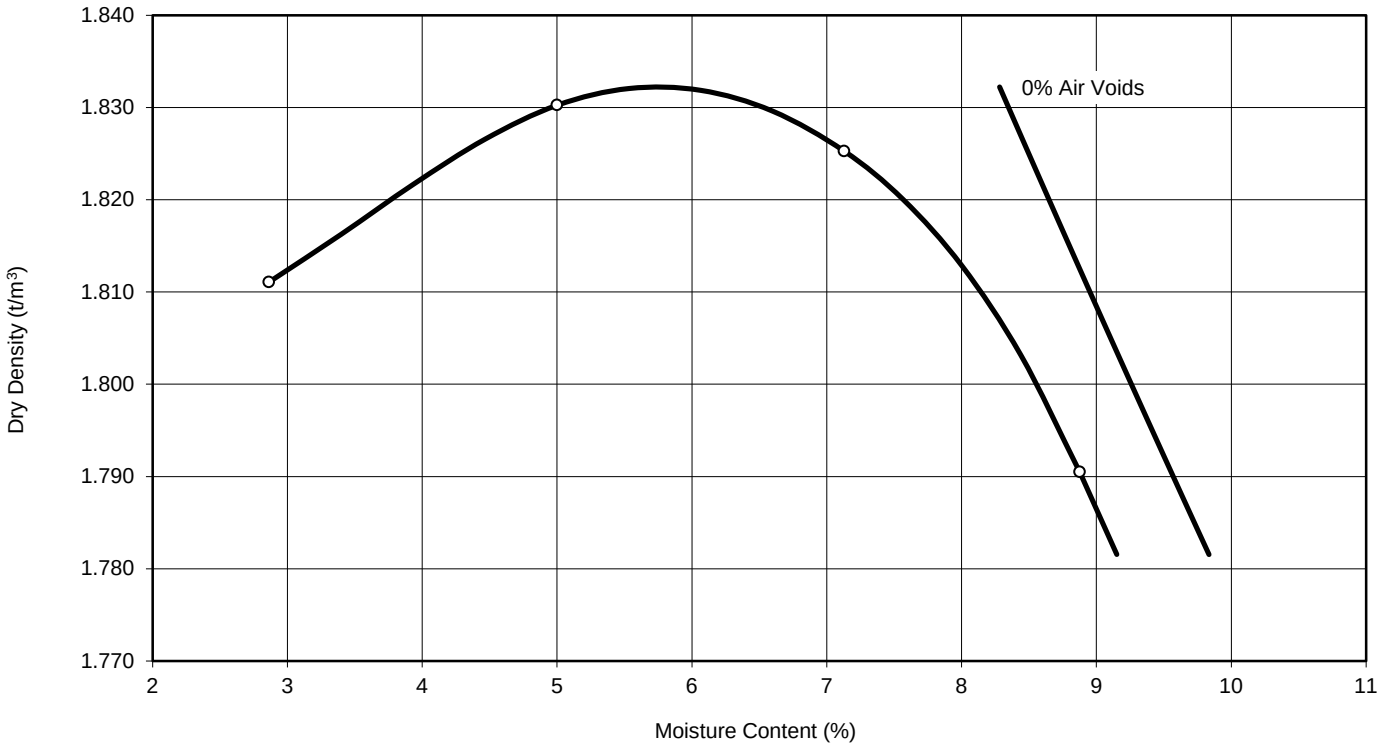
Results of Compaction Test

Client :	Maitland City Bowls Sports and Recreation	**Project No. :**	39498.06
		Report No. :	N15-048_1
Project :	Proposed Synthetic Bowling Greens	**Report Date :**	20.03.2015
Location :	Melbee Street, Rutherford	**Date of Test:**	04.03.2015
		Page:	1 of 1



Sample Details: **Location:** Bore 103
Depth: 0.6m

Particles > 19mm: 0%

Description: Gravelly SAND - Brown

Maximum Dry Density:	**1.83 t/m^3**
Optimum Moisture Content:	**5.5 %**

Remarks:

Test Methods: AS1289.5.1.1, AS1289.2.1.1

Sampling Methods: Sampled by DP Engineering Department

NATA Accredited Laboratory Number: 828
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Tested:	JH
Checked:	DM

Dave Millard
Laboratory Manager

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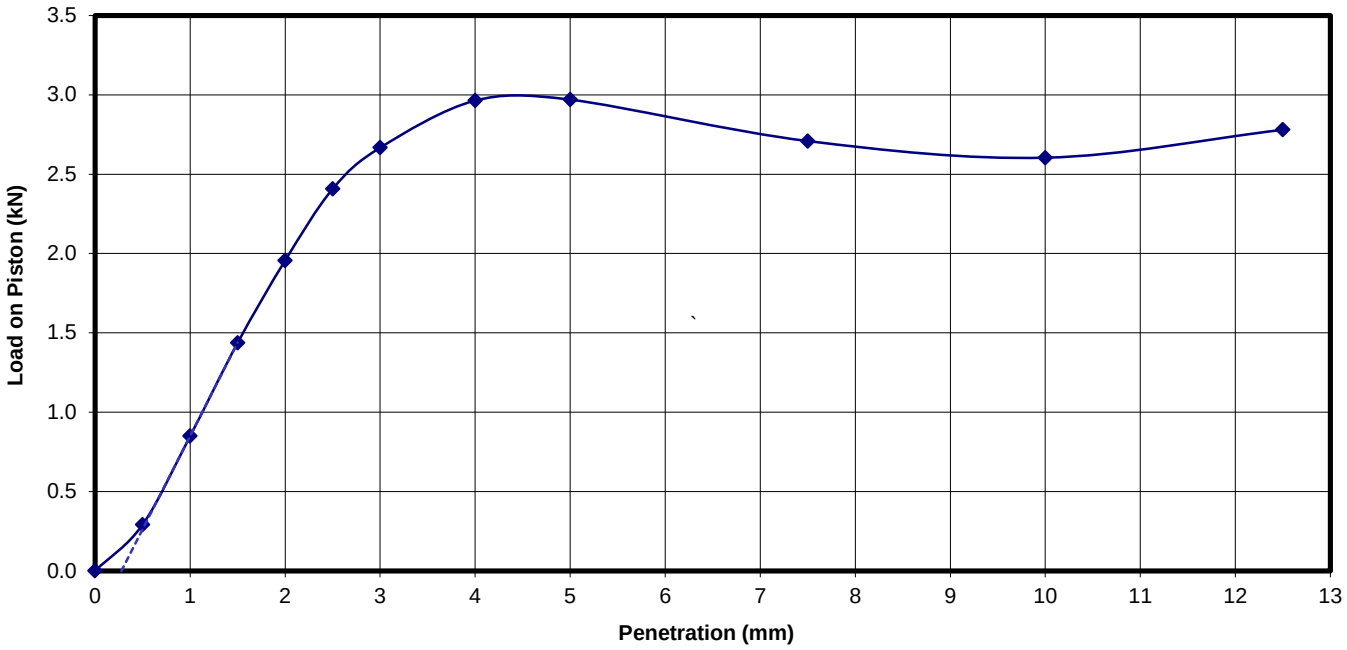
Result of California Bearing Ratio Test

Client :	Maitland City Bowls Sports and Recreation	**Project No. :**	39498.06
		Report No. :	N15-048_2
Project :	Proposed Synthetic Bowling Greens	**Report Date :**	20.03.2015
		Date Sampled :	02.03.2015
Location :	Melbee Street, Rutherford	**Date of Test:**	09.03.2015
Test Location :	Bore 103		
Depth / Layer :	0.6m	**Page:**	1 of 1



Description: Gravelly SAND - Brown

Sampling Method(s): Sampled by DP Engineering Department
Test Method(s): AS 1289.6.1.1, AS 1289.2.1.1

Remarks:

Percentage > 19mm: 0.0%

LEVEL OF COMPACTION: 99.5% of STD MDD
MOISTURE RATIO: 101% of STD OMC
SURCHARGE: 4.5 kg
SOAKING PERIOD: 4 days
SWELL: -0.2%

CONDITION		MOISTURE CONTENT %	DRY DENSITY t/m^3
At compaction		5.6	1.82
After soaking		14.5	1.83
After test	Top 30mm of sample	14.2	-
	Remainder of sample	13.4	-
Field values		9.7	-
Standard Compaction	(OMC/MDD)	5.5	1.83

RESULTS		
TYPE	**PENETRATION**	**CBR (%)**
TOP	**2.5mm**	**19**

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Tested:	DR
Checked:	NH

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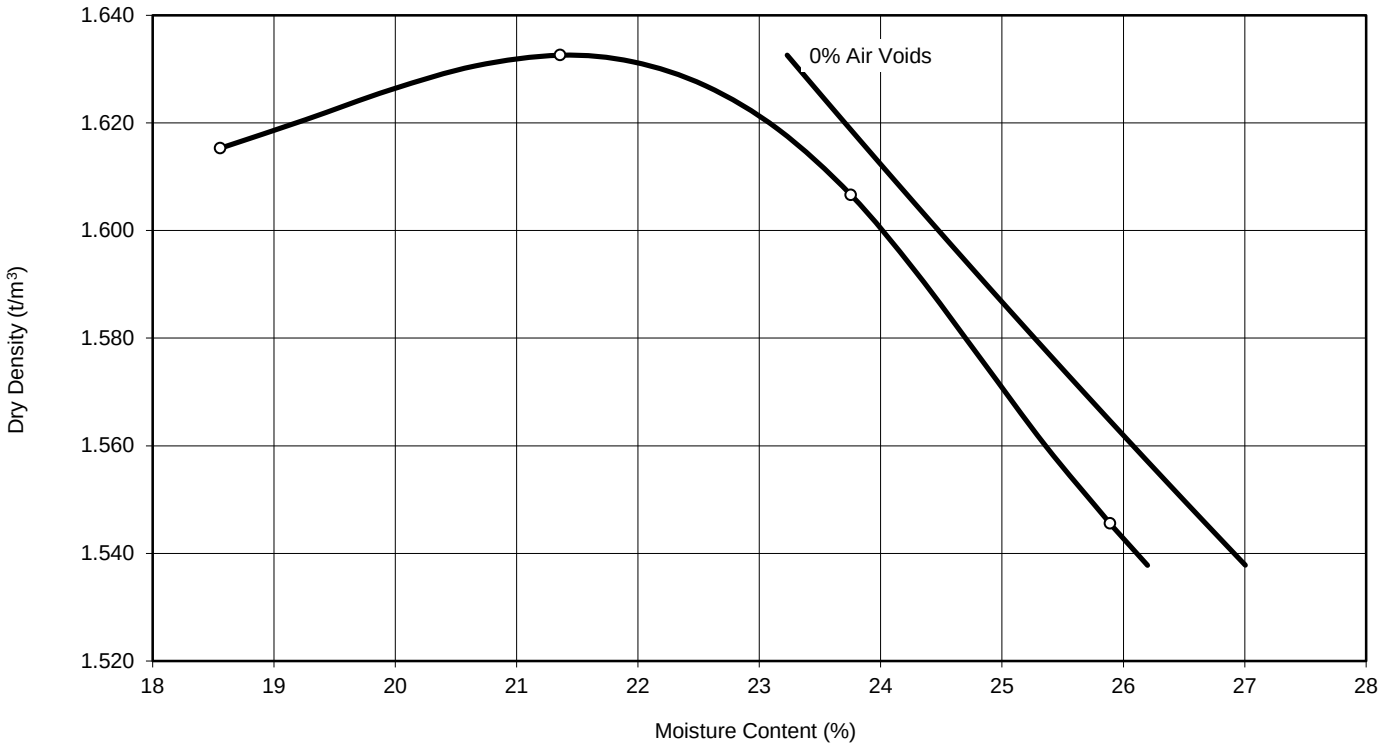
Results of Compaction Test

Client :	Maitland City Bowls Sports and Recreation	**Project No. :**	39498.06
		Report No. :	N15-048_3
Project :	Proposed Synthetic Bowling Greens	**Report Date :**	20.03.2015
Location :	Melbee Street, Rutherford	**Date of Test:**	04.03.2015
		Page:	1 of 1



Sample Details: **Location:** Bore 103
Depth: 0.75m

Particles > 19mm: 0%

Description: Silty CLAY - Orange brown (3% lime)

Maximum Dry Density:	**1.63 t/m^3**
Optimum Moisture Content:	**21.5 %**

Remarks:

Test Methods: RMS T130, RMS T120

Sampling Methods: Sampled by DP Engineering Department

NATA Accredited Laboratory Number: 828
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Tested:	JH
Checked:	DM

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Determination of Unconfined Compressive Strength of Compacted Materials

Client:	**Maitland City Bowls Sports and Recreation**	**Project No:**	39498.06
		Report No:	N15-048_4
Project:	Proposed Synthetic Bowling Greens	**Report Date:**	23.03.2015
		Date Sampled:	02.03.2015
Location:	Melbee Street, Rutherford	**Date of Test:**	12.03.2015
		Page:	1 of 1

Material Retained on 19mm sieve:	-%	
Material Description:	Bore 103 (0.75m) Silty CLAY - Orange brown (3% lime)	
Elapsed time between addition of binder and compaction:	1 hour	
Method of Compaction:	Standard	
No. of layers	3	
Curing Details:	7 day accelerated curing, soaked 4 hours prior to test	
	Specimen A	**Specimen B**
Moisture Content at Compaction:	22.2%	22.2%
Moisture Content after Testing:	-%	-%
Dry Density of test specimens:	1.63 t/m³	1.64 t/m³
Unconfined Compressive Strength:	0.05 MPa	0.10 MPa

AVERAGE UNCONFINED COMPRESSIVE STRENGTH: 0.1 MPa

Test Method(s): RMS T131, RMS T120

Sampling Method(s): Sampled by DP Engineering Department

Remarks:

NATA Accredited Laboratory Number: 828

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Tested: JH
Checked: NH

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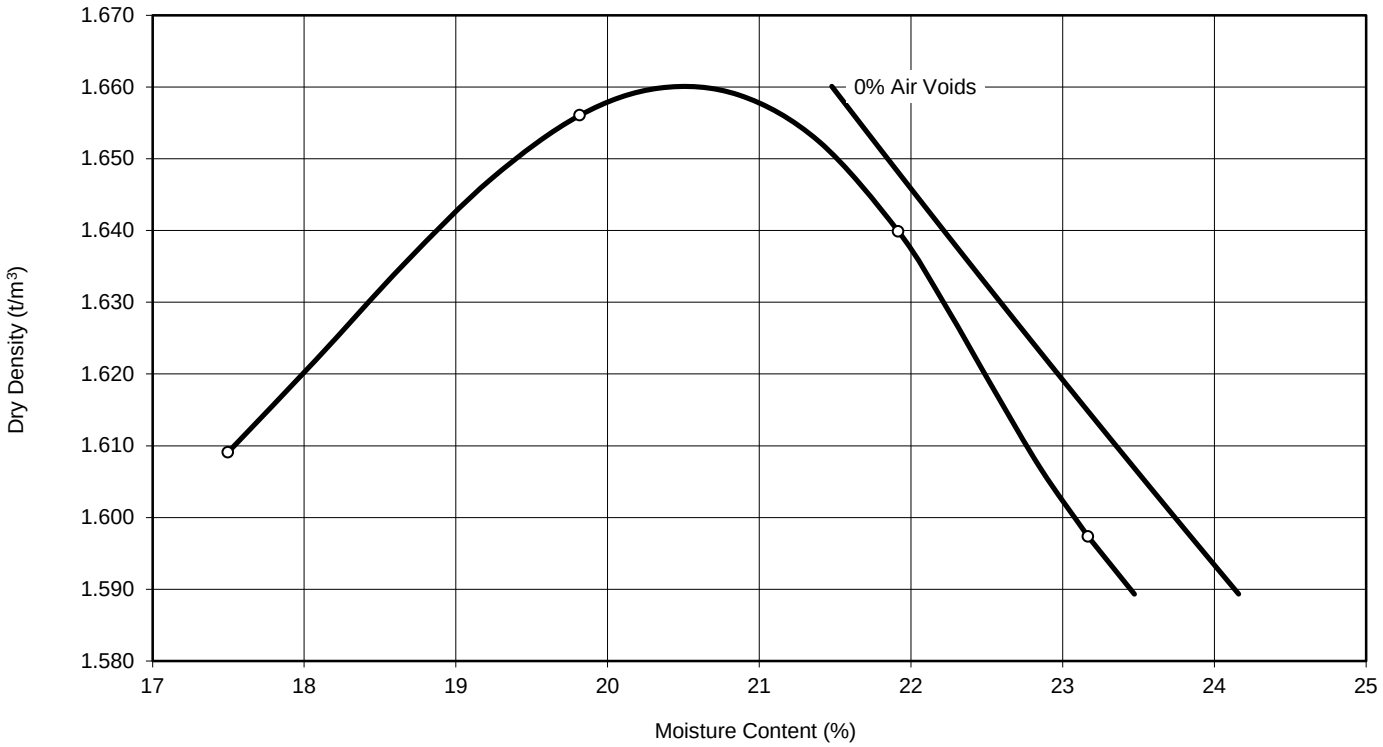
Results of Compaction Test

Client :	Maitland City Bowls Sports and Recreation	**Project No. :**	39498.06
		Report No. :	N15-048_5
Project :	Proposed Synthetic Bowling Greens	**Report Date :**	20.03.2015
Location :	Melbee Street, Rutherford	**Date of Test:**	04.03.2015
		Page:	1 of 1



Sample Details: **Location:** Bore 105
Depth: 0.5m

Particles > 19mm: 0%

Description: FILLING: CLAY - Orange brown (1% lime)

Maximum Dry Density:	**1.66 t/m^3**
Optimum Moisture Content:	**20.5 %**

Remarks:

Test Methods: RMS T130, RMS T120

Sampling Methods: Sampled by DP Engineering Department

NATA Accredited Laboratory Number: 828
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Tested:	JH
Checked:	DM

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Determination of Unconfined Compressive Strength of Compacted Materials

Client:	**Maitland City Bowls Sports and Recreation**	**Project No:**	39498.06
		Report No:	N15-048_6
Project:	Proposed Synthetic Bowling Greens	**Report Date:**	23.03.2015
		Date Sampled:	02.03.2015
Location:	Melbee Street, Rutherford	**Date of Test:**	12.03.2015
		Page:	1 of 1

Material Retained on 19mm sieve:	-%	
Material Description:	Bore 105 (0.5m) FILLING: CLAY - Orange brown (1% lime)	
Elapsed time between addition of binder and compaction:	1 hour	
Method of Compaction:	Standard	
No. of layers	3	
Curing Details:	7 day accelerated curing, soaked 4 hours prior to test	
	Specimen A	**Specimen B**
Moisture Content at Compaction:	21.7%	21.7%
Moisture Content after Testing:	-%	-%
Dry Density of test specimens:	1.65 t/m³	1.65 t/m³
Unconfined Compressive Strength:	- MPa	- MPa

AVERAGE UNCONFINED COMPRESSIVE STRENGTH: - MPa

Test Method(s): RMS T131, RMS T120

Sampling Method(s): Sampled by DP Engineering Department

Remarks: Unconfined Compressive Strength could not be measured due to disintegration of the specimens during soaking

NATA Accredited Laboratory Number: 828

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Tested: JH
Checked: NH

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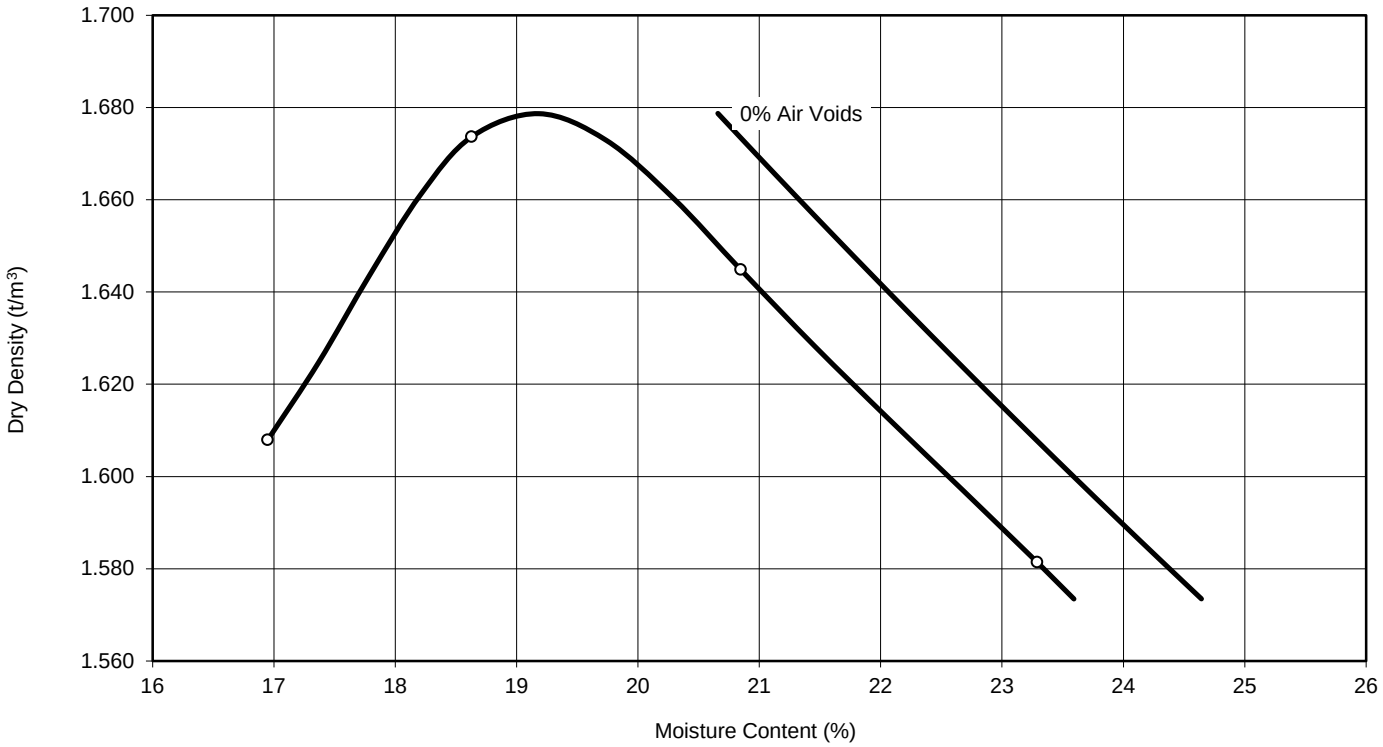
Results of Compaction Test

Client :	Maitland City Bowls Sports and Recreation	**Project No. :**	39498.06
		Report No. :	N15-048_7
Project :	Proposed Synthetic Bowling Greens	**Report Date :**	23.03.2015
Location :	Melbee Street, Rutherford	**Date of Test:**	04.03.2015
		Page:	1 of 1



Sample Details: **Location:** Bore 105
Depth: 0.5m

Particles > 19mm: 0%

Description: FILLING: CLAY - Orange brown (3% lime)

Maximum Dry Density:	**1.68 t/m^3**
Optimum Moisture Content:	**19.0 %**

Remarks:

Test Methods: RMS T130, RMS T120

Sampling Methods: Sampled by DP Engineering Department

NATA Accredited Laboratory Number: 828
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Tested:	JH
Checked:	DM

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Determination of Unconfined Compressive Strength of Compacted Materials

Client:	**Maitland City Bowls Sports and Recreation**	**Project No:**	39498.06
		Report No:	N15-048_8
Project:	Proposed Synthetic Bowling Greens	**Report Date:**	23.03.2015
		Date Sampled:	02.03.2015
Location:	Melbee Street, Rutherford	**Date of Test:**	12.03.2015
		Page:	1 of 1

Material Retained on 19mm sieve:	-%	
Material Description:	Bore 105 (0.5m) FILLING: CLAY - Orange brown (3% lime)	
Elapsed time between addition of binder and compaction:	1 hour	
Method of Compaction:	Standard	
No. of layers	3	
Curing Details:	7 day accelerated curing, soaked 4 hours prior to test	
	Specimen A	**Specimen B**
Moisture Content at Compaction:	20.4%	20.4%
Moisture Content after Testing:	-%	-%
Dry Density of test specimens:	1.64 t/m³	1.63 t/m³
Unconfined Compressive Strength:	- MPa	- MPa

AVERAGE UNCONFINED COMPRESSIVE STRENGTH: - MPa

Test Method(s): RMS T131, RMS T120

Sampling Method(s): Sampled by DP Engineering Department

Remarks: Unconfined Compressive Strength could not be measured due to disintegration of the specimens during soaking

NATA Accredited Laboratory Number: 828

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Tested: JH
Checked: NH

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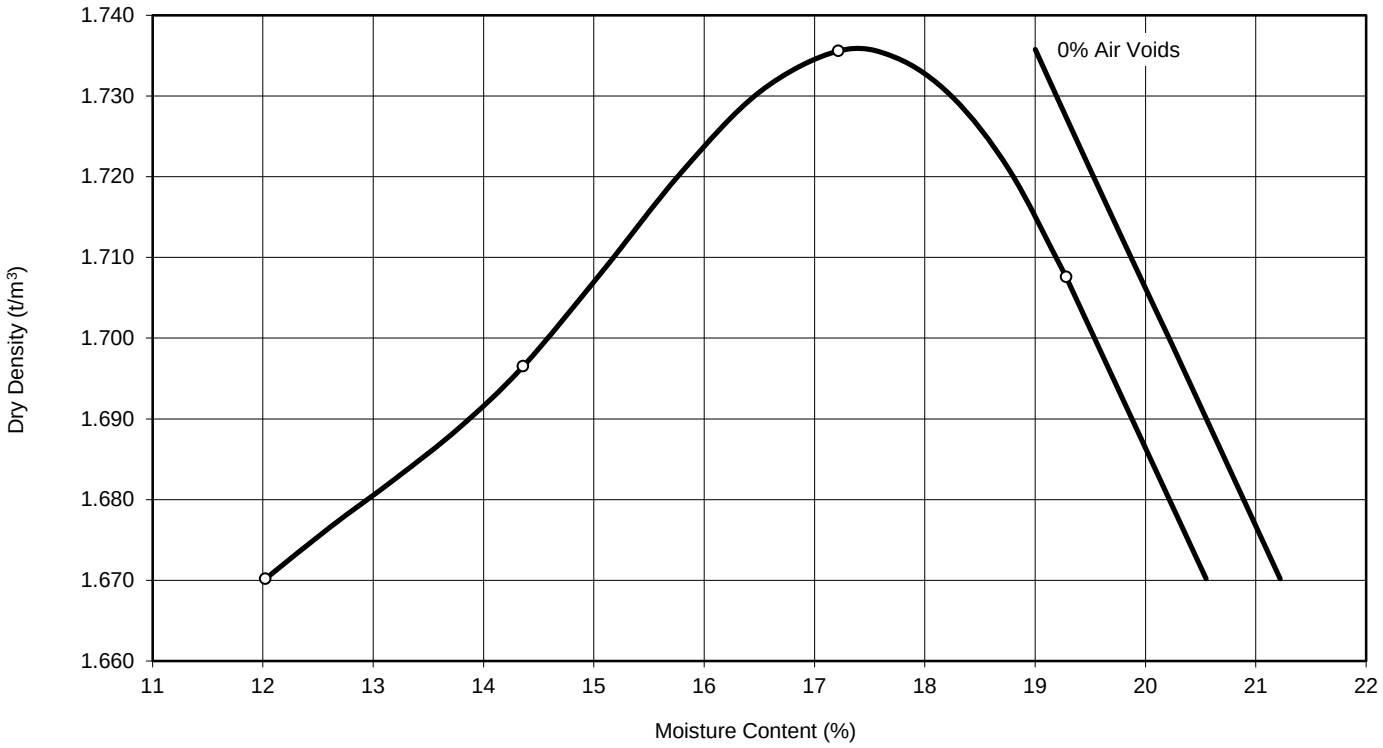
Results of Compaction Test

Client :	Maitland City Bowls Sports and Recreation	**Project No. :**	39498.06
		Report No. :	N15-048_9
Project :	Proposed Synthetic Bowling Greens	**Report Date :**	23.03.2015
Location :	Melbee Street, Rutherford	**Date of Test:**	05.03.2015
		Page:	1 of 1



Sample Details: **Location:** Bore 105
Depth: 1.0m

Particles > 19mm: 0%

Description: FILLING: CLAY - Pale brown (1% lime)

Maximum Dry Density:	**1.74 t/m^3**
Optimum Moisture Content:	**17.5 %**

Remarks:

Test Methods: RMS T130, RMS T120

Sampling Methods: Sampled by DP Engineering Department

NATA Accredited Laboratory Number: 828
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Tested:	JH
Checked:	DM

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Determination of Unconfined Compressive Strength of Compacted Materials

Client:	**Maitland City Bowls Sports and Recreation**	**Project No:**	39498.06
		Report No:	N15-048_10
Project:	Proposed Synthetic Bowling Greens	**Report Date:**	23.03.2015
		Date Sampled:	02.03.2015
Location:	Melbee Street, Rutherford	**Date of Test:**	19.03.2015
		Page:	1 of 1

Material Retained on 19mm sieve:	-%	
Material Description:	Bore 105 (1.0m) FILLING: CLAY - Pale brown (1% lime)	
Elapsed time between addition of binder and compaction:	1 hour	
Method of Compaction:	Standard	
No. of layers	3	
Curing Details:	7 day accelerated curing, unsoaked prior to test	
	Specimen A	**Specimen B**
Moisture Content at Compaction:	17.7%	17.7%
Moisture Content after Testing:	-%	-%
Dry Density of test specimens:	1.79 t/m³	1.82 t/m³
Unconfined Compressive Strength:	0.01 MPa	0.01 MPa

AVERAGE UNCONFINED COMPRESSIVE STRENGTH: 0.0 MPa

Test Method(s): RMS T131, RMS T120

Sampling Method(s): Sampled by DP Engineering Department

Remarks: Average UCS rounded to nearest 0.1 MPa

NATA Accredited Laboratory Number: 828

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Tested: JH
Checked: NH

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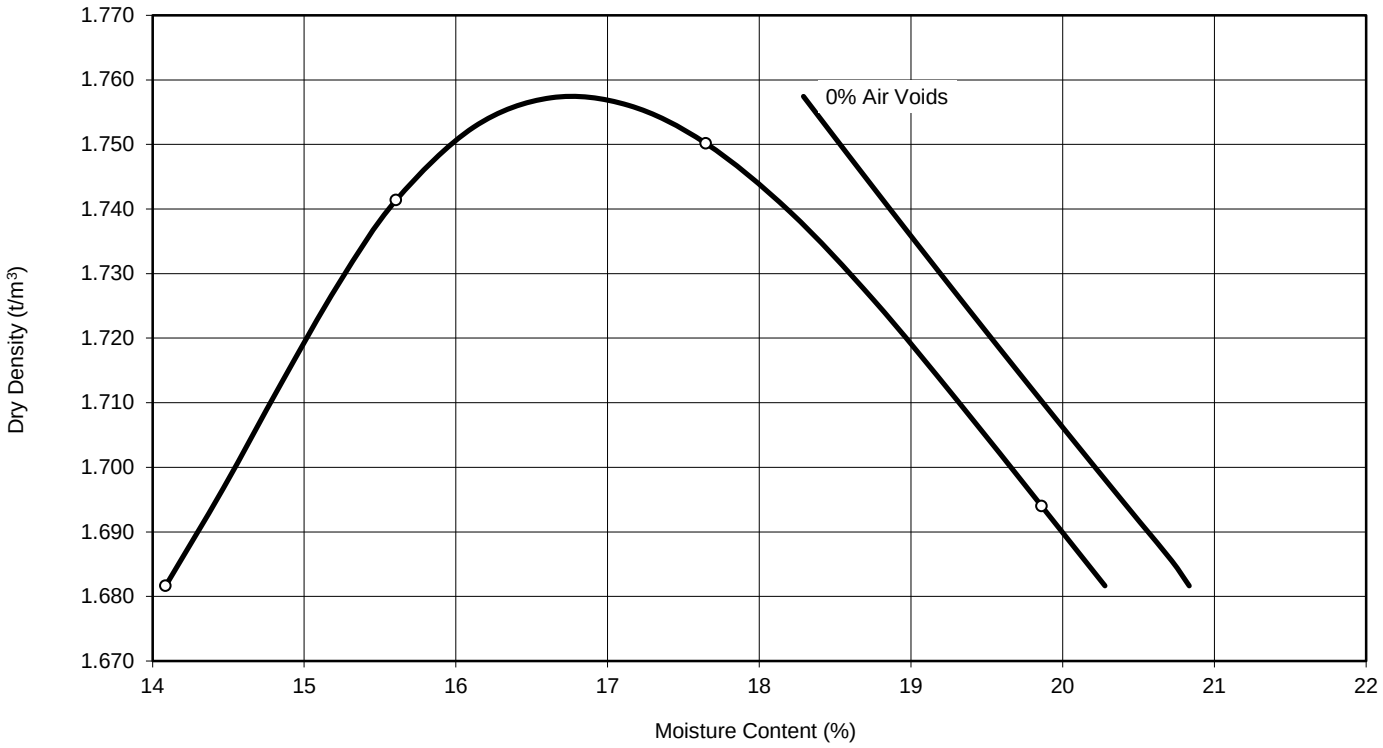
Results of Compaction Test

Client :	Maitland City Bowls Sports and Recreation	**Project No. :**	39498.06
		Report No. :	N15-048_11
Project :	Proposed Synthetic Bowling Greens	**Report Date :**	23.03.2015
Location :	Melbee Street, Rutherford	**Date of Test:**	04.03.2015
		Page:	1 of 1



Sample Details: **Location:** Bore 105
Depth: 1.0m

Particles > 19mm: 0%

Description: FILLING: CLAY - Pale brown (3% lime)

Maximum Dry Density:	**1.76 t/m^3**
Optimum Moisture Content:	**17.0 %**

Remarks:

Test Methods: RMS T130, RMS T120

Sampling Methods: Sampled by DP Engineering Department

NATA Accredited Laboratory Number: 828
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Tested:	JH
Checked:	DM

Dave Millard
Laboratory Manager

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Determination of Unconfined Compressive Strength of Compacted Materials

Client:	**Maitland City Bowls Sports and Recreation**	**Project No:**	39498.06
		Report No:	N15-048_12
Project:	Proposed Synthetic Bowling Greens	**Report Date:**	23.03.2015
		Date Sampled:	02.03.2015
Location:	Melbee Street, Rutherford	**Date of Test:**	12.03.2015
		Page:	1 of 1

Material Retained on 19mm sieve:	-%	
Material Description:	Bore 105 (1.0m) FILLING: CLAY - Pale brown (3% lime)	
Elapsed time between addition of binder and compaction:	1 hour	
Method of Compaction:	Standard	
No. of layers	3	
Curing Details:	7 day accelerated curing, unsoaked prior to test	
	Specimen A	**Specimen B**
Moisture Content at Compaction:	17.0%	17.0%
Moisture Content after Testing:	-%	-%
Dry Density of test specimens:	1.68 t/m³	1.71 t/m³
Unconfined Compressive Strength:	- MPa	- MPa

AVERAGE UNCONFINED COMPRESSIVE STRENGTH: - MPa

Test Method(s): RMS T131, RMS T120

Sampling Method(s): Sampled by DP Engineering Department

Remarks: Unconfined Compressive Strength could not be measured due to disintegration of the specimens

NATA Accredited Laboratory Number: 828

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. Accredited for compliance with ISO/IEC 17025

Tested: JH
Checked: NH

Dave Millard
Laboratory Manager

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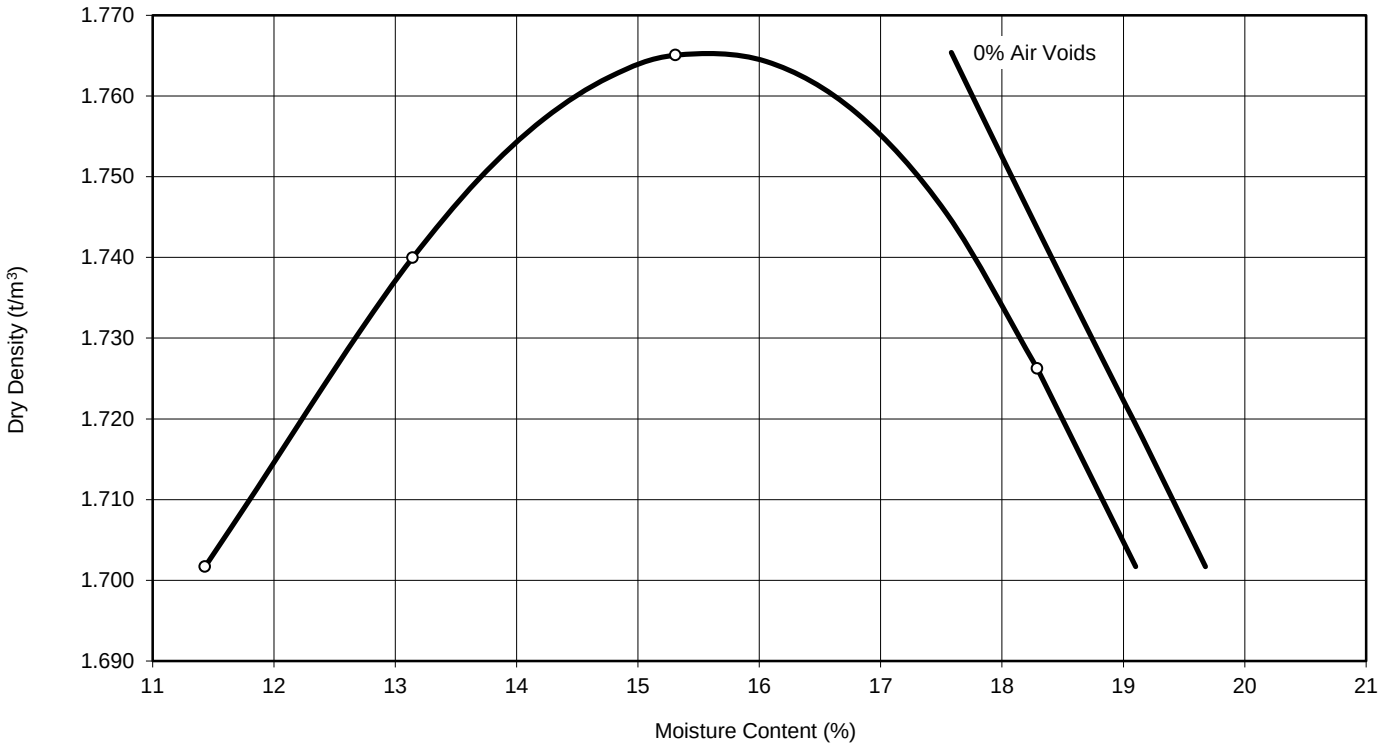
Results of Compaction Test

Client :	Maitland City Bowls Sports and Recreation	**Project No. :**	39498.06
		Report No. :	N15-048_13
Project :	Proposed Synthetic Bowling Greens	**Report Date :**	23.03.2015
Location :	Melbee Street, Rutherford	**Date of Test:**	05.03.2015
		Page:	1 of 1



Sample Details: **Location:** Bore 105
Depth: 1.3m

Particles > 19mm: 0%

Description: FILLING: CLAY - Pale brown (3% lime)

Maximum Dry Density:	**1.77 t/m^3**
Optimum Moisture Content:	**15.5 %**

Remarks:

Test Methods: RMS T130, RMS T120

Sampling Methods: Sampled by DP Engineering Department

NATA Accredited Laboratory Number: 828
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. Accredited for compliance with ISO/IEC 17025

Tested:	JH
Checked:	DM

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Determination of Unconfined Compressive Strength of Compacted Materials

Client:	**Maitland City Bowls Sports and Recreation**	**Project No:**	39498.06
		Report No:	N15-048_14
Project:	Proposed Synthetic Bowling Greens	**Report Date:**	23.03.2015
		Date Sampled:	02.03.2015
Location:	Melbee Street, Rutherford	**Date of Test:**	19.03.2015
		Page:	1 of 1

Material Retained on 19mm sieve:	-%	
Material Description:	Bore 105 (1.3m) FILLING: CLAY - Pale brown (3% lime)	
Elapsed time between addition of binder and compaction:	1 hour	
Method of Compaction:	Standard	
No. of layers	3	
Curing Details:	7 day accelerated curing, unsoaked prior to test	
	Specimen A	**Specimen B**
Moisture Content at Compaction:	15.9%	15.9%
Moisture Content after Testing:	-%	-%
Dry Density of test specimens:	1.81 t/m³	1.82 t/m³
Unconfined Compressive Strength:	0.05 MPa	0.05 MPa

AVERAGE UNCONFINED COMPRESSIVE STRENGTH: 0.1 MPa

Test Method(s): RMS T131, RMS T120

Sampling Method(s): Sampled by DP Engineering Department

Remarks:

NATA Accredited Laboratory Number: 828

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. Accredited for compliance with ISO/IEC 17025

Tested: JH
Checked: NH

Dave Millard
Laboratory Manager

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Results of Moisture Content, Plasticity and Linear Shrinkage Tests

Client:	**Maitland City Bowls Sports and Recreation**	**Project No:**	39498.06
		Report No:	N15-048_15
Project:	Proposed Synthetic Bowling Greens	**Report Date:**	23.03.2015
		Date Sampled:	02.03.2015
Location:	Melbee Street, Rutherford	**Date of Test:**	09.03.2015
		Page:	1 of 1

Test Location	Depth (m)	Description	Code	W_F %	W_L %	W_P %	PI %	*LS %
Bore 103	0.75	Silty CLAY – Orange brown	2,5	23.3	61	12	49	16.5
Bore 105	0.5	FILLING: CLAY – Orange brown	2,5	25.7	65	11	54	14.0 (CU)

Legend:

W_F Field Moisture Content
W_L Liquid limit
W_P Plastic limit
PI Plasticity index
LS Linear shrinkage from liquid limit condition (Mould length125mm)

Test Methods:

Moisture Content: AS 1289 2.1.1
Liquid Limit: AS 1289 3.1.2
Plastic Limit: AS 1289 3.2.1
Plasticity Index: AS 1289 3.3.1
Linear Shrinkage: AS 1289 3.4.1

Code:

Sample history for plasticity tests

1. Air dried
2. Low temperature (<50ºC) oven dried
3. Oven (105ºC) dried
4. Unknown

Method of preparation for plasticity tests

5. Dry sieved
6. Wet sieved
7. Natural

*Specify if sample crumbled CR or curled CU

Sampling Methods: Sampled by DP Engineering Department

Remarks:

NATA Accredited Laboratory Number: 828

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. Accredited for compliance with ISO/IEC 17025

Tested: DR
Checked: DM

Dave Millard
Laboratory Manager

Appendix C

Drawing 1 – Test Location Plan

Legend

300 mm diameter bore 75 mm diameter bore 75 mm diameter bore (Previous Investigation)

Douglas Partners Geotechnics / Environment / Groundwater	**Approximate Location of Tests** **Proposed Synthetic Bowling Greens, Melbee Street, Rutherford**	PROJECT: 39498.06 DWG No: 1 REV: A
	CLIENT: Maitland City Bowls Sports and Recreation	DATE: 30.03.2015